

**Research Article****Clinico-Pathological Correlation and the Effects of Septal Surgery on Nasal Mucociliary Clearance****R. G. Mariappan<sup>1</sup>, M. Dhanalakshmi<sup>2</sup>, Dony Manattu Mathaikutty<sup>3\*</sup>, Ruta Shanmugam<sup>4</sup>, V. U. Shanmugam<sup>5</sup>, Balaji Swaminathan<sup>6</sup>, Srikanth Nandipati<sup>7</sup>**<sup>1,5</sup>Professor, <sup>3</sup>Post Graduate, <sup>4</sup>Professor & HOD, <sup>6</sup>Reader, <sup>7</sup>Lecturer, Dept. of ENT, <sup>2</sup>Reader, Dept. of Pathology, Rajah Muthiah Medical College, Annamalai University, Annamalai nagar, Chidambaram, Tamilnadu-608002, India**\*Corresponding author**

Dr. Dony Manattu Mathaikutty

Email: [drdondmk@gmail.com](mailto:drdondmk@gmail.com)

---

**Abstract:** Nasal mucociliary clearance is an important defensive mechanism of the nose. Nasal obstruction may lead to histological alterations in the nasal mucosa and also impair the mucociliary function. It is speculated that the nasal septal deviation, the commonest cause of nasal obstruction, disturbs the mucociliary activity in the nose. The purpose of the present study is to investigate the differences in mucociliary clearance preoperatively as well as postoperatively following septal surgery and to study histological characteristics of bilateral nasal septal mucosa in patients with deviated septum. Mucociliary transport was measured by saccharine test in both nasal cavities in 20 patients with septal deviation preoperatively and postoperatively in the first month following septal surgery. Their septal mucosae were taken during surgery, and the histological differences in the lamina propria of the septal mucosae were compared under a light microscope. Nasal mucociliary transport was also measured bilaterally in 18 of those patients, three months following surgery. Clinically the concave side showed longer saccharine clearance time than the convex side. Histopathologically, the inflammatory cells heavily infiltrated the concave side with less seromucinous glands. Saccharine clearance time improved three months after surgery. So we conclude that the concave-side septal mucosae have impaired mucociliary transport, presumably due to increased inflammation and decreased density of the glandular acini and that the surgeries for a deviated septum have positive effects on the mucociliary clearance mechanism.**Keywords:** Nasal mucociliary clearance, Saccharine clearance time, Concave side, Convex side, Deviated nasal septum, Septal surgery

---

**INTRODUCTION**

The nasal septum is a vital structure which provides supportive role and affects the intranasal airflow pattern. The nasal septum contributes to the temperature and moisture of the inhaled air to make it more suitable for the body and also filters the air using its ciliated mucosa [1].

The severity of septal deviations, their location, shape and complexity all influence airflow dynamics in the nasal cavity. Thus, in the nasal cavities of subjects with nasal septal deviation, a difference may occur in the amount of airflow and resistance. In response to this difference, a compensatory hypertrophy of the nasal mucosa on the side opposite the major septal deviation is often found. In addition to the compensatory hypertrophy, an impaired mucociliary clearance, higher incidence of osteomeatal complex obstruction, and increased incidence of sinusitis on the concave side have been reported in subjects with deviated nasal septum [2, 3].

The nasal cavity and the sinuses are lined by pseudo stratified ciliated columnar epithelium. Beneath this is the tunica propria formed by fibroblastic tissue containing mucous glands and serous glands. The secretions of these glands combine and form a biphasic mucous blanket that covers the epithelium. The upper layer of the mucous blanket is highly viscous, elastic, and tenacious (gel phase), whereas the lower layer is of lower viscosity, which enables the cilia to move the blanket forwards (sol phase). This blanket and the ciliated epithelium form the so-called mucociliary system. The mean velocity of the mucus flow and particle transport in a normal nose is about 5 mm/min reaching upto more than 20 mm/min [4].

Radioactive particles placed on the septum travelled posteriorly to the soft palate, either passing in a gentle slope to the inferior edge of the septum or travelling directly posteriorly and then taking a sharp turn towards the inferior edge of the septum. Those on the floor of the nose travel posteriorly, but tend to deviate either laterally to the inferior meatus or medially towards the

inferior edge of the nasal septum during their passage to the nasopharynx. Particles placed on the medial surface of the inferior turbinate pass laterally to the inferior meatus and then posteriorly. They then pass above or below the tubal opening [5].

Where there is an obstruction to the normal path of the mucociliary transport, different phenomena have been reported. Where spurs on the septum or other mucosal irregularities present large obstructions or are associated with alterations in the epithelial surface such as squamous metaplasia, the pathway is around these obstructions. If the bony spur is small and has retained functioning ciliated epithelium on its surface, and the mucus is of adequate viscosity to move up a slope, then the mucus blanket will travel over this obstacle. If there is a defect in the mucosal surface, and the cohesive properties of the mucus are preserved then the mucus carpet can move undisturbed from one edge of intact epithelium to the next. If there is a defect associated with pooling of the mucus or with squamous metaplasia, the normal mucociliary transport will be lost at this site [5].

Nasal mucociliary clearance is a fundamental function required to maintain the health and defense of the nose by trapping and transporting airborne particles. Mucociliary transport is disturbed in a variety of conditions which affects the activity of the cilia [5]. Congenital abnormalities in the structural constitution or function of the cilia (Kartagener's triad, primary ciliary dyskinesia) can interfere easily with normal ciliary activity. Dryness can affect the ciliary activity significantly. At 50% relative humidity of inspired air, ciliary action stops after 8-10 min and at 30% relative humidity of inspired air, it stops after 3-5 min. regarding the temperature, ciliary activity ceases at a range of 7-12°C. Other factors such as locally applied drugs, inhaled gases, environmental exposure to large amounts of wood dust and chromium vapors, tobacco smoke or infection can severely impair the ciliary function [4].

Measurement of mucociliary function can be separated into three types of studies;

- measurement of ciliary form and motion
- measurement of mucus production and its chemical and physical properties
- measurement of the efficiency of the combined effects of the mucus and ciliary systems - saccharine test [5].

Many *in vivo* and *in vitro* techniques have been used for the measurement of mucociliary clearance. *In vitro* techniques such as stroboscopy, photon-electron techniques and phase contrast microscopy determines the ciliary beat frequency. However, they are too expensive and not suitable for routine use. *In vivo* techniques such as saccharine, charcoal and radionuclide's using rhinoscintigraphy can be

performed easily and are not expensive. Mucociliary clearance is commonly assessed by means of the saccharine clearance time, which was originally described in 1974 [6-8]. The saccharine clearance time has been the primary research tool for determining the effects of environmental, microbiological or pharmacologic variables on nasal mucociliary clearance rate [7].

The method commonly used is a modification of Andersen's original description of the test. Patients who have a saccharine clearance time greater than 20 min have disturbed nasal mucociliary transport and those with times greater than 60 min having significantly disturbed mucociliary transport. In these patients it is necessary to confirm their ability to taste saccharine [5].

In this study, we estimated the mucociliary clearance on both sides of the deviated nasal septum and estimated its correlation histologically. We also studied the post operative effect of septal surgery on the nasal mucociliary clearance.

## MATERIALS AND METHODS

20 patients of the age group of 18-50 years with symptomatic deviated nasal septum, diagnosed clinically were selected for the study. Each nose was tested separately on different days for mucociliary clearance using saccharine test. A 1-mm-diameter or quarter fragment of a saccharine tablet was placed on the septal mucosa at the junction with the floor, just medial to the anterior end of the inferior turbinate. Patients head was kept forwards and was asked to sit quietly, not to sniff, sneeze, eat, or drink. The time taken for the first perception of the sweet taste was recorded. Saccharine test was done preoperatively and post operatively during the first and third month. As a control, the saccharin test was also done on one side in 20 healthy volunteers (aged 18-50 years) with normal septum.

During septal surgery, 0.5x0.5cm septal mucosa was taken from different points on either side of the septum. Mucosal pieces were fixed in 10% formalin, embedded in paraffin, and stained with hematoxylin-eosin. Histologically, the distribution of the nasal glands and the density of the inflammatory infiltrates were studied under x100 magnification.

### Inclusion Criteria

- Presenting with nasal obstruction
- Epistaxis due to spur
- Otitis media due to deviated septum
- Patients presenting with anosmia due to deviated septum

### Exclusion Criteria

- Minor spur
- S-shaped deviation
- Nasal polyp

- Allergic rhinitis
- Sinusitis
- Asymptomatic septal deviation

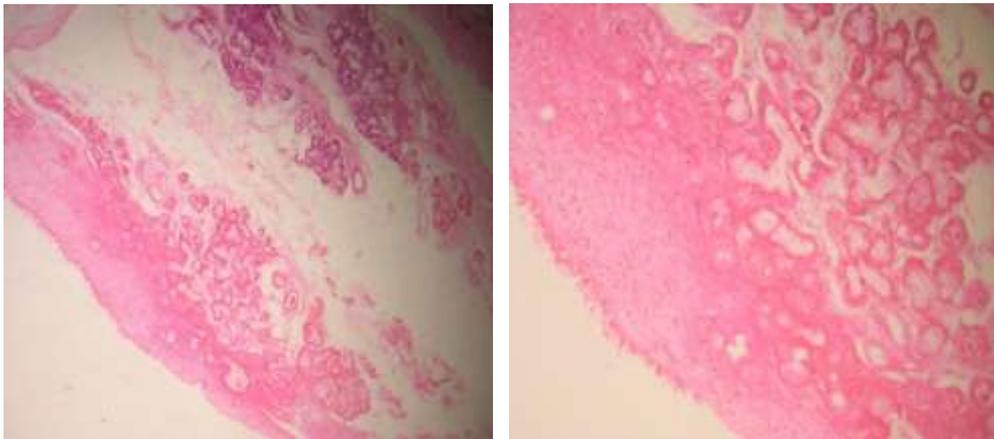
**RESULTSS**

In our study, preoperative mucociliary clearance on the concave side was significantly longer when compared to that on the convex side ( $p < 0.01$ ) and the control ( $p < 0.01$ ). However, there was no significant difference in the mucociliary clearance between the convex side preoperatively and the control ( $p > 0.05$ ).

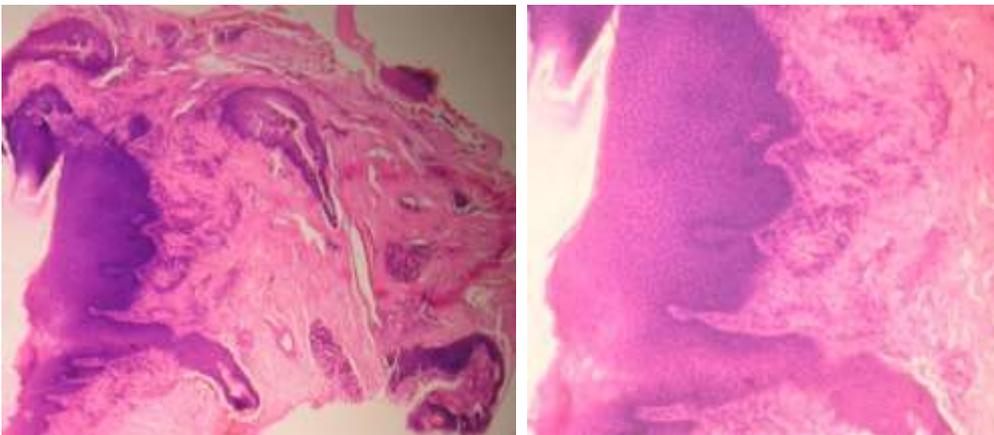
Histological findings of the septal mucosa on either side of the septum in 18 patients showed dense inflammatory infiltrate with reduced number of mucosal

glands on the concave side and scanty inflammatory infiltrate with dense mucosal glands on the convex side. Two cases were void because the specimens were insufficient for examination.

Post operative mucociliary clearances done during the first month in 20 patients were found to be still impaired in both the nasal cavities with no significant difference when compared to that done preoperatively ( $p > 0.05$  for both). Post operative mucociliary clearances were estimated only in 18 patients during the third month, as two patients failed to review on the third month. Significant improvement in the mucociliary clearances were found on the third month following surgery ( $p < 0.05$ ).



**Fig. 1: Low and high power view of convex septal mucosa showing pseudostratified ciliated columnar epithelium with dense mucosal glands and few inflammatory cells**



**Fig. 2: Low and high power view of the concave septal mucosa showing squamous metaplasia with numerous inflammatory cells and very few mucosal glands**

**Table 1: Descriptive analysis**

| Number of cases | SCT                                 | Mean  | Std. Deviation |
|-----------------|-------------------------------------|-------|----------------|
| 20              | Pre op SCT concave (min)            | 17.85 | 2.477          |
| 20              | Pre op SCT convex (min)             | 12.90 | 1.252          |
| 20              | 1st month post op SCT concave (min) | 18.45 | 2.064          |
| 20              | 1st month post op SCT convex (min)  | 13.15 | 1.309          |
| 18              | 3rd month post op SCT concave (min) | 14.61 | 1.243          |
| 18              | 3rd month post op SCT convex (min)  | 11.11 | 1.278          |
| 20              | Control SCT (min)                   | 12.60 | 1.903          |

## DISCUSSION

In the present study, the saccharine clearance time (SCT) was prolonged on the concave nasal cavity ( $17.85 \pm 2.48$  minutes) when compared to the convex side preoperatively ( $12.90 \pm 1.25$  minutes) and the control ( $12.60 \pm 1.90$  minutes). Previous investigators have also reported significantly increased SCT in patients with nasal septal deviation [3, 9, 10]. Yong Ju Jang *et al.* in 1999 studied the mucociliary transport and histological characteristics of the mucosa of deviated nasal septum in 20 patients and found that the concave side, convex side and the right and left nasal cavities of the control had a mean SCT of about  $16.52 \pm 8.06$ ,  $12.36 \pm 4.83$ ,  $11.36 \pm 4.33$ ,  $11.06 \pm 3.53$  minutes respectively. They concluded that the concave-side septal mucosa had impaired mucociliary transport and no impairment was seen on the convex side when compared to the control [3]. V. K. Pandya *et al.* in 2006 reported a mean mucociliary clearance time of 30.2 minutes and a mean mucociliary clearance rate of 4.3 mm/min in their study involving patients with deviated septum (18-60 yrs) as against a mean mucociliary clearance time of 9.5 minutes and a mean mucociliary clearance rate of 12.7 mm/min in normal adults (18-60 yrs). They found that SCT was significantly prolonged in patients with DNS [10].

In our study, the prolonged SCT found preoperatively in the study group showed no change postoperatively after one month (concave -  $18.45 \pm 2.06$  minutes, convex -  $13.15 \pm 1.31$  minutes). Improvement in the SCT was found on the third month after surgery (concave -  $14.61 \pm 1.24$  minutes, convex -  $11.11 \pm 1.28$  minutes). Oner Sakallioğlu *et al.* in 2012 studied the effect of septoplasty on nasal mucociliary clearance in 20 patients. They reported a mean SCT of  $14.03 \pm 1.68$ ,  $14.04 \pm 4.43$  and  $10.39 \pm 1.16$  minutes in the preoperative, post operative 1st month and postoperative 3rd month respectively as compared to a mean SCT of  $8.79 \pm 2.63$  minutes in the control group. They concluded that septoplasty operation positively affects the mucociliary mechanism [11]. G. Fyrmpas *et al.* in 2011 studied the nasal mucociliary clearance in patients undergoing septoplasty in 30 adult patients and concluded that the mucociliary transport remained abnormal for the first two months post operatively [12]. Cahit Polat *et al.* in 2009 evaluated the nasal mucociliary transport rate by rhinoscintigraphy before and after surgery in patients with deviated nasal septum and found that on the concave and convex sides, the average third month post-operative nasal mucociliary transport rate (NMTR) value was higher than the first month post-operative NMTR values. It was concluded that the septoplasty operation improves reduced NMTRs after surgery and its effect on nasal mucociliary activity may be more accurately evaluated in the third month than the first month of the post-operative period [13].

In our study, infiltration of inflammatory cells was more prominent in the concave-side septal mucosa than

in the convex. Yong Ju Jang *et al.* in 1999 also reported a similar account in their study. It can be due to a spontaneous inflammatory process, not related to allergy or infection, brought about in the more open nasal cavity by increased airflow [3].

As for the decreased distribution of the glandular tissue in our study, it is possible that a chronic inflammatory process of the concave-side septal mucosa, as demonstrated in our study, may lead to stromal proliferation and fibrosis of the lamina propria, resulting in relative paucity of the glandular acini [3].

Yong Ju Jang *et al.* in 1999 found that the concave-side septal mucosa revealed more severe loss of cilia under scanning electron microscopic examination when compared to the convex side [3]. Abdulsalam Hussein *et al.* in 2005 studied the nasal mucosal morphology after alteration of air stream in 15 adult rabbits and concluded that on the side with sealed nostril the number of goblet cells was increased, while the numbers of ciliated cells were decreased. In contrast, on the open side of the nose, disappearance of the ciliated cells and a transformation of the respiratory epithelium into thickened multilayered squamous epithelium with no goblet cells were seen [14]. These findings help us to justify the decreased mucociliary clearance on the concave side.

Mucociliary clearance is a primary defense mechanism of the upper and lower airways and disruption of this process, whether acquired or inherited, predisposes an individual to chronic nasal, paranasal sinus, and airway infection [15, 16]. Differences in the mucociliary transport (MCT) rates between different sites in the nose depend on ciliary beat frequency, density of the ciliary population, length of the cilia, and mucus quality [3]. The results of our study, which revealed impaired MCT on the concave nasal cavity, can certainly be explained by the decreased ciliary population (not examined in our study) on the concave side, indicating a loss of mucociliary machinery. Additionally, a change in the property of the mucus covering the epithelium can result from increased inflammatory infiltrates and reduced distribution of glandular tissue which might have contributed to the impaired MCT on the concave side.

In conclusion, the results of our study suggests that nasal septal deviation is not a simple affliction resulting only in a mechanical alteration of nasal airflow in the nasal cavity, but a more complex disease process presenting with impaired mucociliary clearance on the concave-side mucosa. This result is probably due to increased inflammation and decreased density of the glandular acini on the concave septal mucosa. Septal surgeries can significantly improve the SCT after 3 months.

## CONCLUSION

Patients with deviated nasal septum have impaired muco-ciliary clearance on the concave side. This is supported by the histological findings which shows that the concave septal mucosa have numerous inflammatory infiltrates with less mucosal glands when compared to the convex septal mucosa. Septal surgery can improve the muco-ciliary clearance, which can be appreciated post operatively in the third month.

## REFERENCES

1. Naxakis S, Athanasopoulos I, Vlastos IM, Giannakenas C, Vassilakos P, Goumas P; Evaluation of nasal mucociliary clearance after medical or surgical treatment of chronic rhinosinusitis. *Eur Arch Otorhinolaryngol.*, 2009; 266(9):1423-1426.
2. Yigit O, Akgul G, Alkan S, Uslu B, Dadas B; Changes occurring in the nasal mucociliary transport in patients with one-sided septum deviation. *Rhinology*, 2005; 43(4): 257-260.
3. Jang YJ, Myong NH, Park KH, Koo TW, Kim HG; Mucociliary transport and histologic characteristics of the mucosa of deviated nasal septum. *Arch Otolaryngol Head Neck Surg.*, 2002; 128(4): 421-424.
4. Watelet JB, Cauwenberge PV; Applied anatomy and physiology of the nose and paranasal sinuses. *Allergy*, 1999; 54(57): 14-25.
5. Lale M, Mason JDT, Jones NS; Mucociliary transport and its assessment: a review. *Clin Otolaryngol.*, 1998; 23(5): 388-396.
6. Lee LM, Gendeh BS; Pre and post treatment mucociliary function in allergic rhinitis in three different treatment modalities. *Med J Malaysia*, 2003; 58(1):17-20.
7. Littlejohn MC, Stiernberg CM; Hokanson JA, Quinn FB Jr, Bailey BJ; The relationship between the nasal cycle and mucociliary clearance. *Laryngoscope*, 1992; 102(2):117-120.
8. Ranga RK, Yadav J, Singh J; Nasal mucociliary clearance in allergic rhinitis in children. *Clinical Rhinology: An International Journal*, 2010; 3(2): 93-95.
9. Kamani T, Yilmaz T, Surucu S, Turan E, Brent KA; Scanning electron microscopy of Ciliae and Saccharine test for ciliary function in septal deviations. *Laryngoscope*, 2006; 116(4): 586-590.
10. Pandya VK, Tiwari RS; Nasal mucociliary clearance in health and disease. *Indian J Otolaryngol Head Neck Surg.*, 2006; 58(4): 332-334.
11. Sakallıoglu O, Duzer S, Kapusuz Z, Soylu E; The evaluation of nasal mucociliary activity after septoplasty and external septorhinoplasty. *Indian J Otolaryngol Head Neck Surg.*, 2013; 65(Suppl 2): 360-365.
12. Fyrmpas G, Rachovitsas D, Tsalighopoulos M, Constantinidis J; Nasal mucociliary clearance in patients undergoing septoplasty: a clinical study. *Otorhinolaryngologia - Head and Neck Surgery*, 2011; 43:18-25.
13. Polat C, Dostbil Z; Evaluation of the nasal mucociliary transport rate by rhinoscintigraphy before and after surgery in patients with deviated nasal septum. *Eur Arch Otorhinolaryngol.*, 2010; 267(4): 529-535.
14. Hussein A, Awadalla R; Nasal mucosal morphology after alteration of air stream. *The Egyptian Journal of Hospital Medicine*, 2006; 25:578-585.
15. Valía PP, Valero FC, Pardo JM, Rentero DB, Monte CG; Saccharin test for the study of mucociliary clearance: reference values for a spanish population. *Arch Bronconeumol.*, 2008; 44(10): 540-545.
16. Birdi SM, Singh S, Singh A; Mucociliary clearance in chronic sinusitis. *IJO & HNS*, 1998; 50(1):15-19.